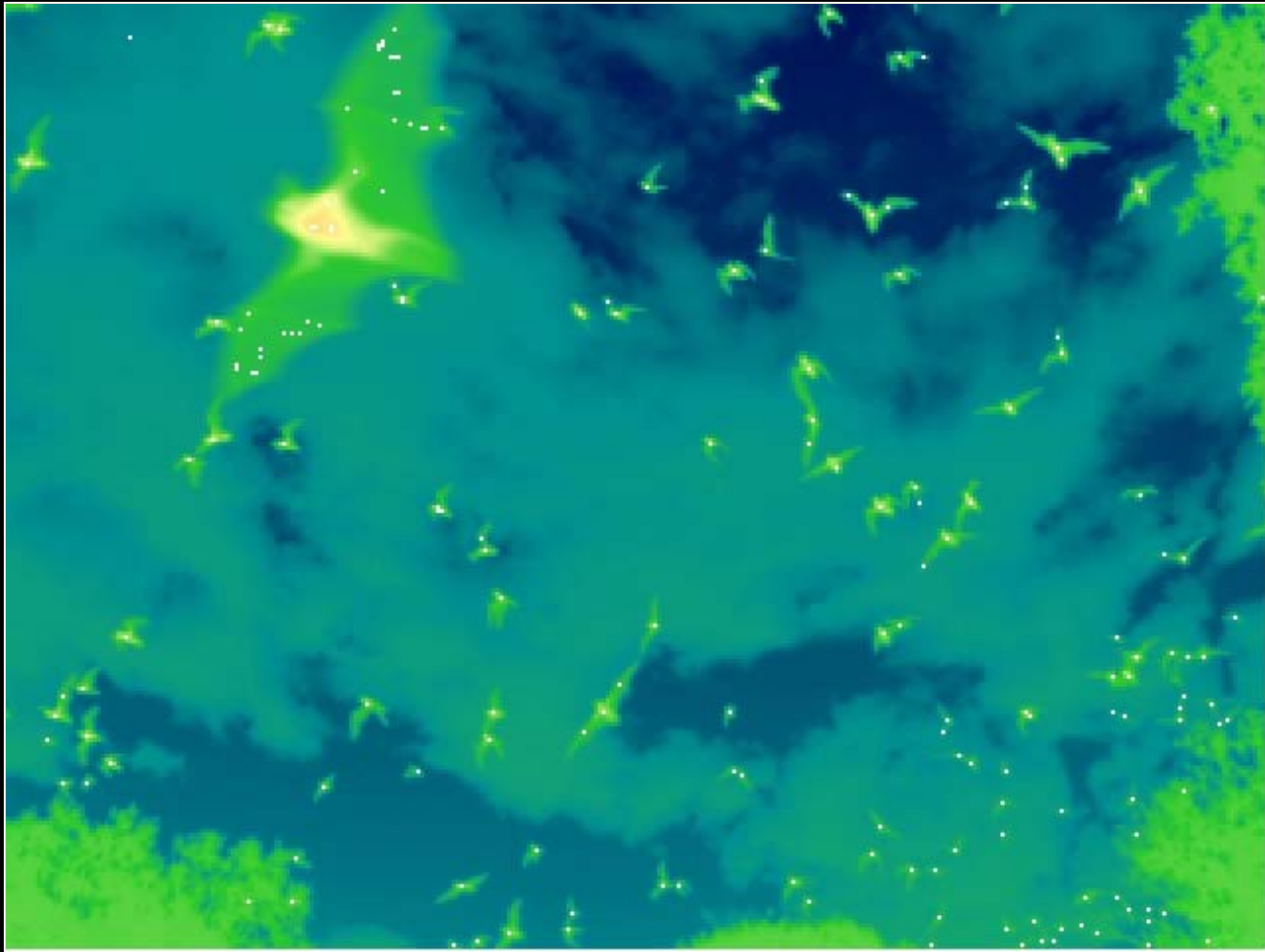
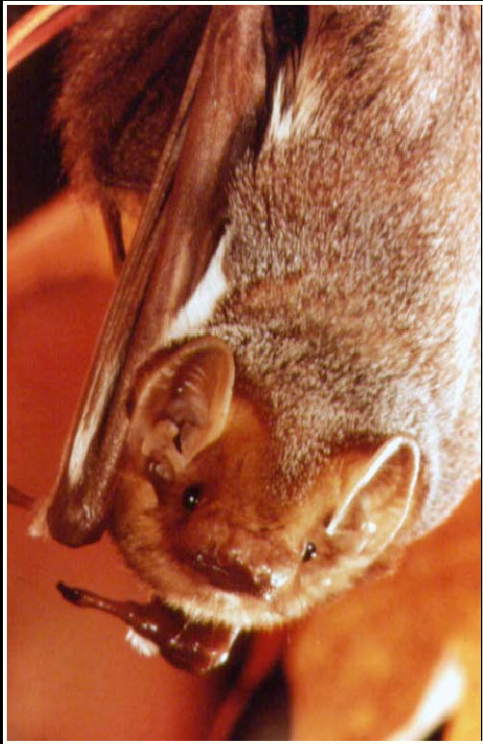


Bats at Risk: Why Should We Care?

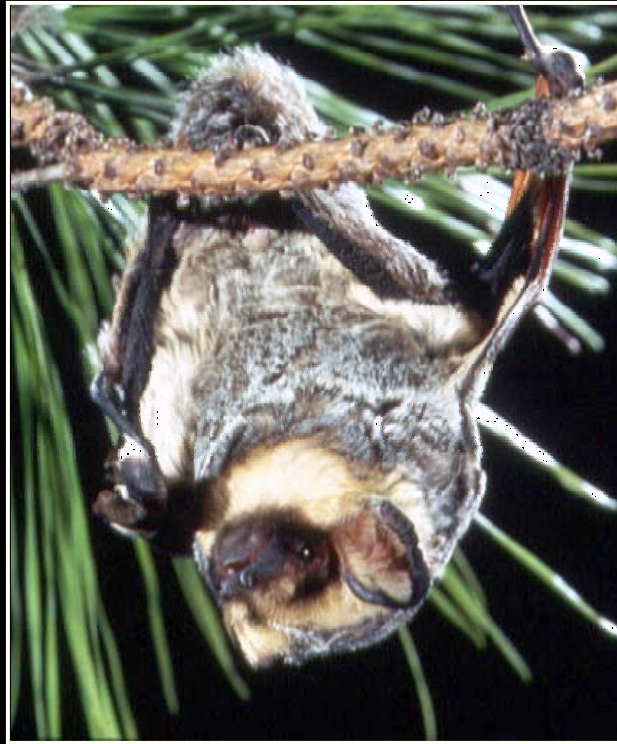


Thomas H. Kunz
Boston University

Three of 45 North American Migratory Bat Species are Most Often Killed by Wind Turbines



Eastern Red Bat



Hoary Bat



Silver-haired Bat

Where Have all the Eastern Red Bat's Gone?

A Very Brief History

"During the latter part of October and the first week of November, I have seen great flights of [eastern red bats] during the whole day." (Mearns, 1898).

"Recent studies indicate that migratory tree bats (especially eastern red bats and hoary bats) appear to be in decline" (Carter et al. 2003; Whitaker et al. 2002; Winhold et al. 2005).

The Future

Cumulative Impacts ??

Why Are Bats at Risk?

Human Attitudes (most people don't love bats!)

- Myths and Folklore

- Bad Press

- Ignorance

Anthropogenic Factors

- Deforestation

- Global Climate Change

- Habitat Alteration

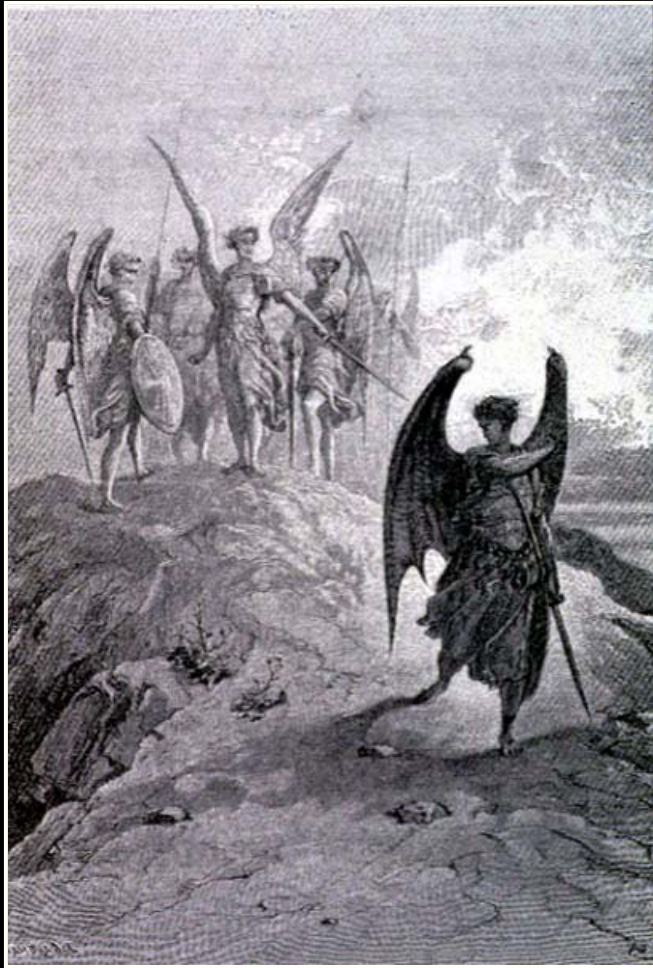
- Mining

- Pesticides

- Water Pollution

- Wind Turbines

Myths and Folklore



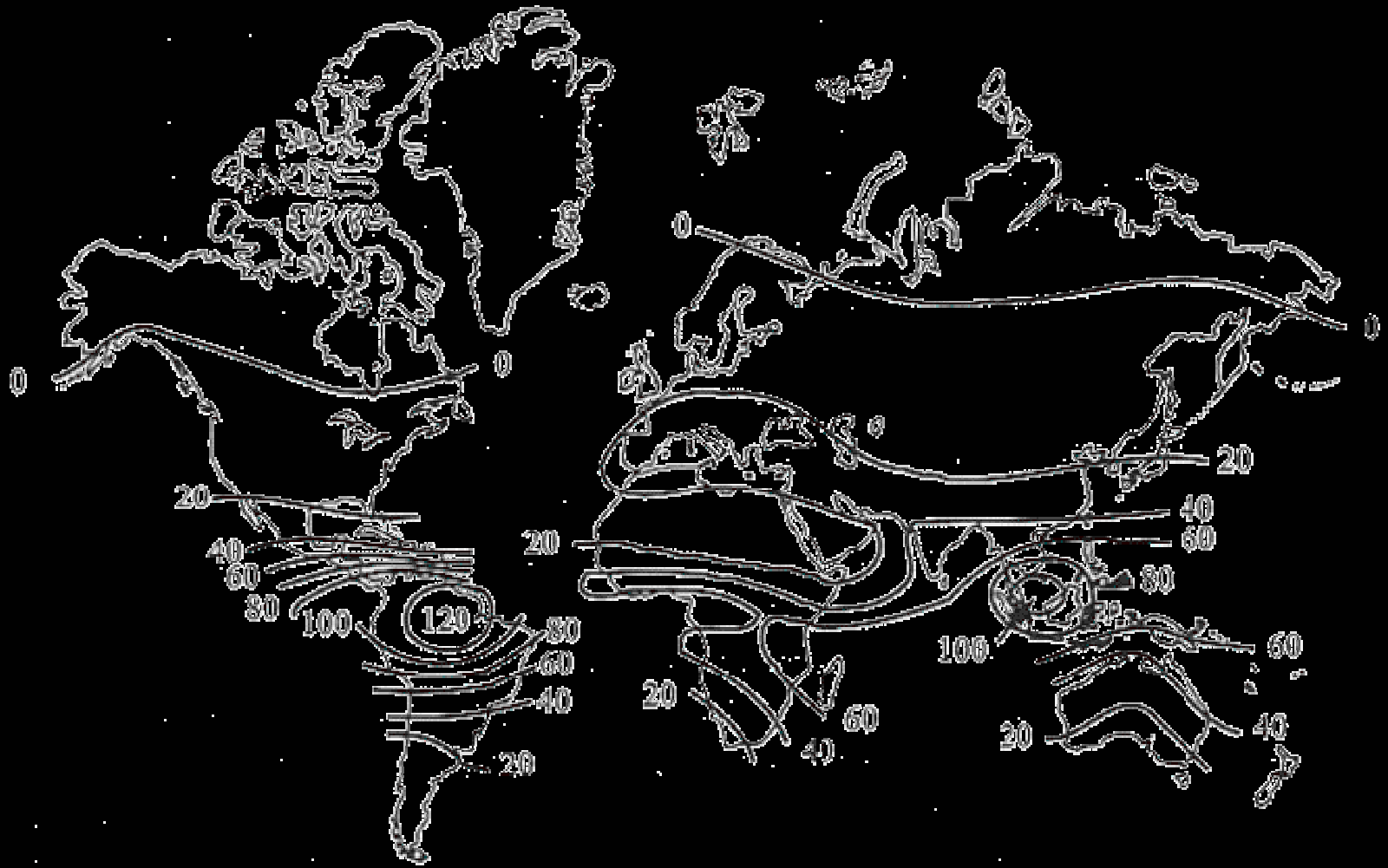
Fallen Angels



Stewed Angels

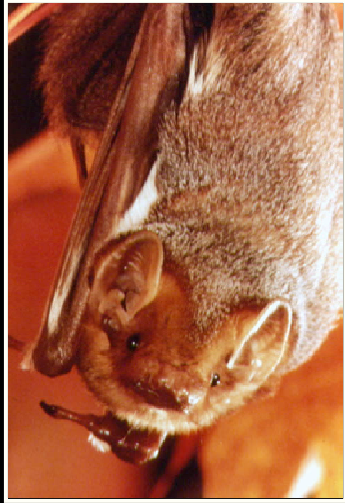
Bats 101

Global Pattern of Bat Species Richness



1116 Bat Species Recognized (ca. 20% of Extant Mammalian Fauna)

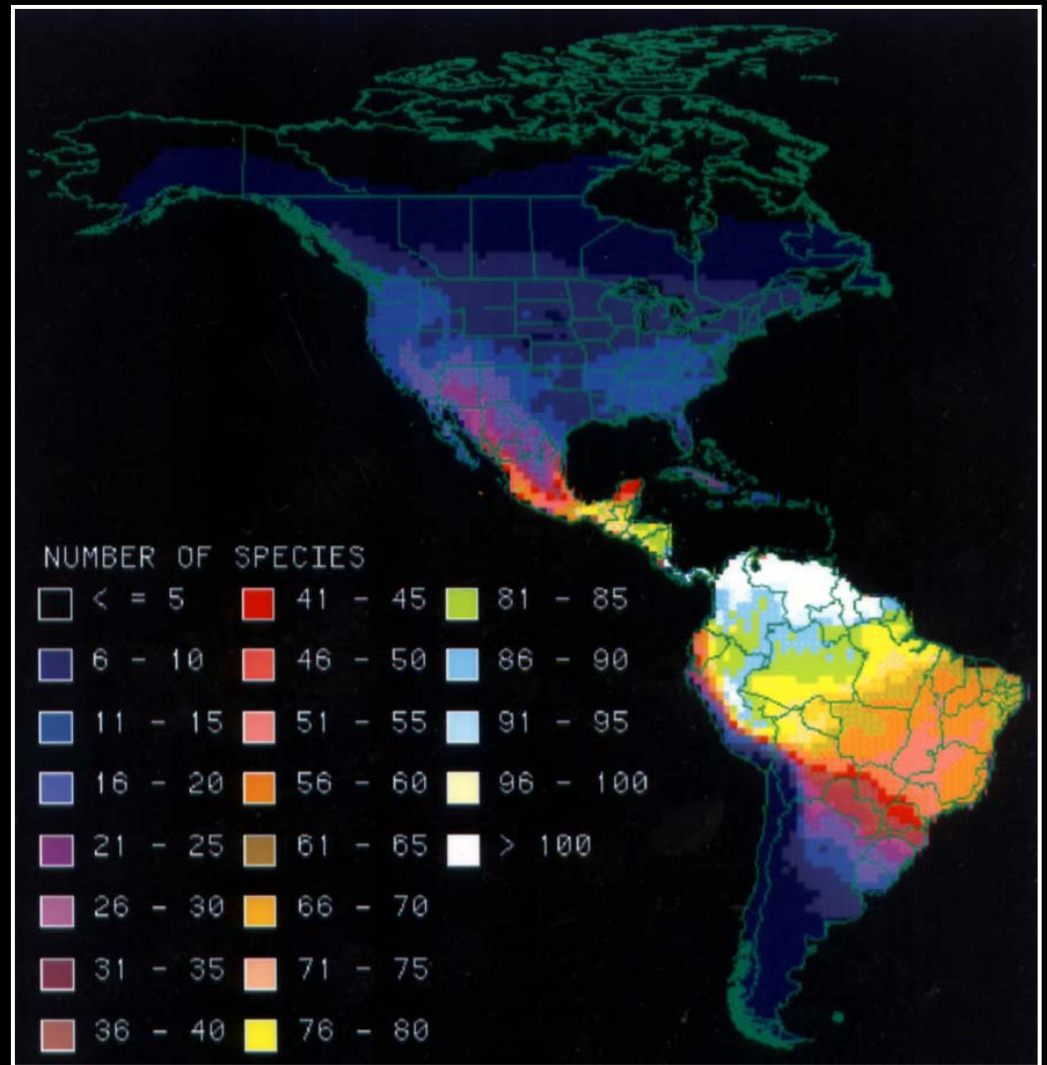
Species Richness of New World Bats



Eastern red bat



Long-nosed bat



Number of Species

Bats

Distinguished from all Other Mammals by
their Ability for Powered Flight



Brazilian Free-tailed Bats (*Tadarida brasiliensis*)

Trophic (Feeding) Diversity

Bats have evolved a diverse array of trophic specializations

Photo by Merlin Tuttle



Insectivory



Frugivory



Nectarivory



Piscivory



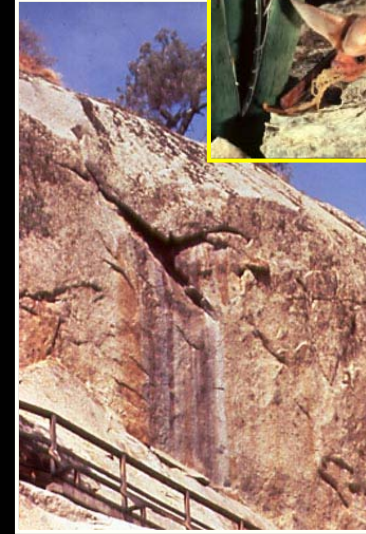
Carnivory



Photo by Tom Kunz

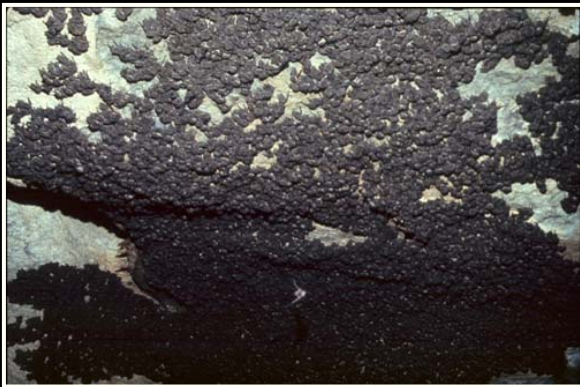
Sanguivory

Natural Roosts



Tree Cavities

Rock Crevices



Caves



Foliage

Human-Made Roosts



Barns



Houses



Bridges



Mines



Bat Houses



Unique Life-History Traits

Size at Birth



Pups Average 25% of
Mother's Body Mass at Birth

Size at Weaning



Mothers Nurse Their
Pups Until they are
Nearly Adult Size

Relevant Life-History Traits of Bats

- Females typically reach reproductive maturity within first year following birth
- Males typically reach sexual maturity in second year of birth
- Low reproductive rate (typically one litter/year)
- Prolonged gestation period (> 2-8 months)
- Small litter size: typically 1 pup annually (range = 1 to 4)
- Long life span (3 x greater than other mammals of comparable body size)

Bat Echolocation

Frequency Modulated (FM) Pulses

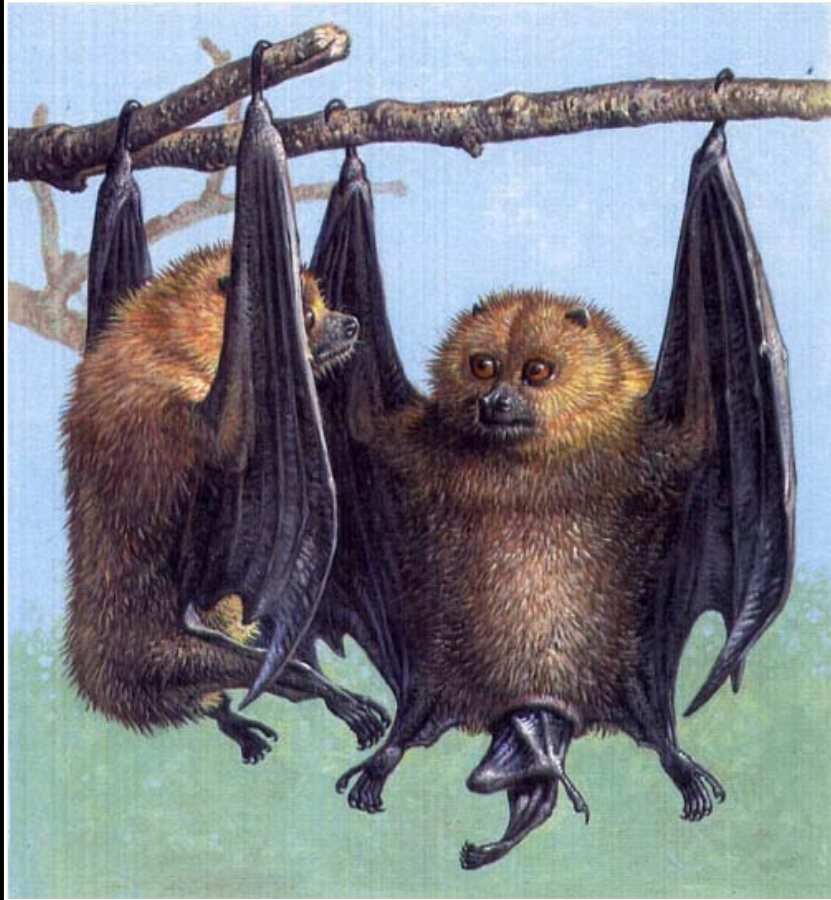
Constant Frequency (CF) Pulses

Quasi Constant Frequency (QCF) Pulses



Schnitzler and Kalko 1998

Two Extraordinary Traits of Bats



Alloparental Care

(Kunz et al. 1994)



Male Lactation

(Francis et al. 1994)

Hibernation



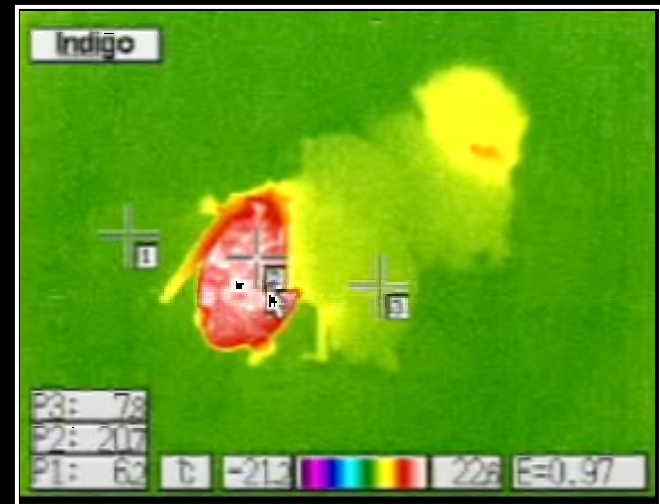
Hibernating Cave Myotis



Hibernating Gray Bats



Sperm Embedded in Uterine Lining of Hibernating Female

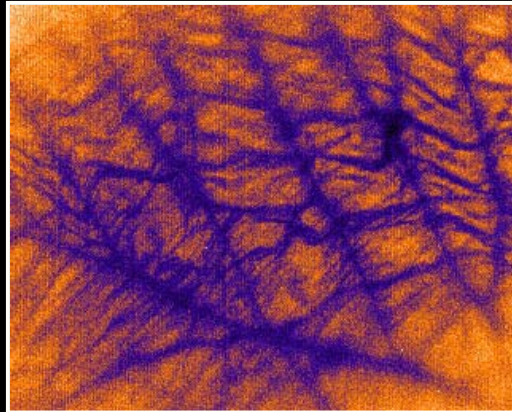


Little Brown Myotis Arousing from Torpor

Benefits of Bats to Human Societies



Biomedical



Food



Art/Culture



Fertilizer

Bats Provide Important Ecosystem Services



Pollination



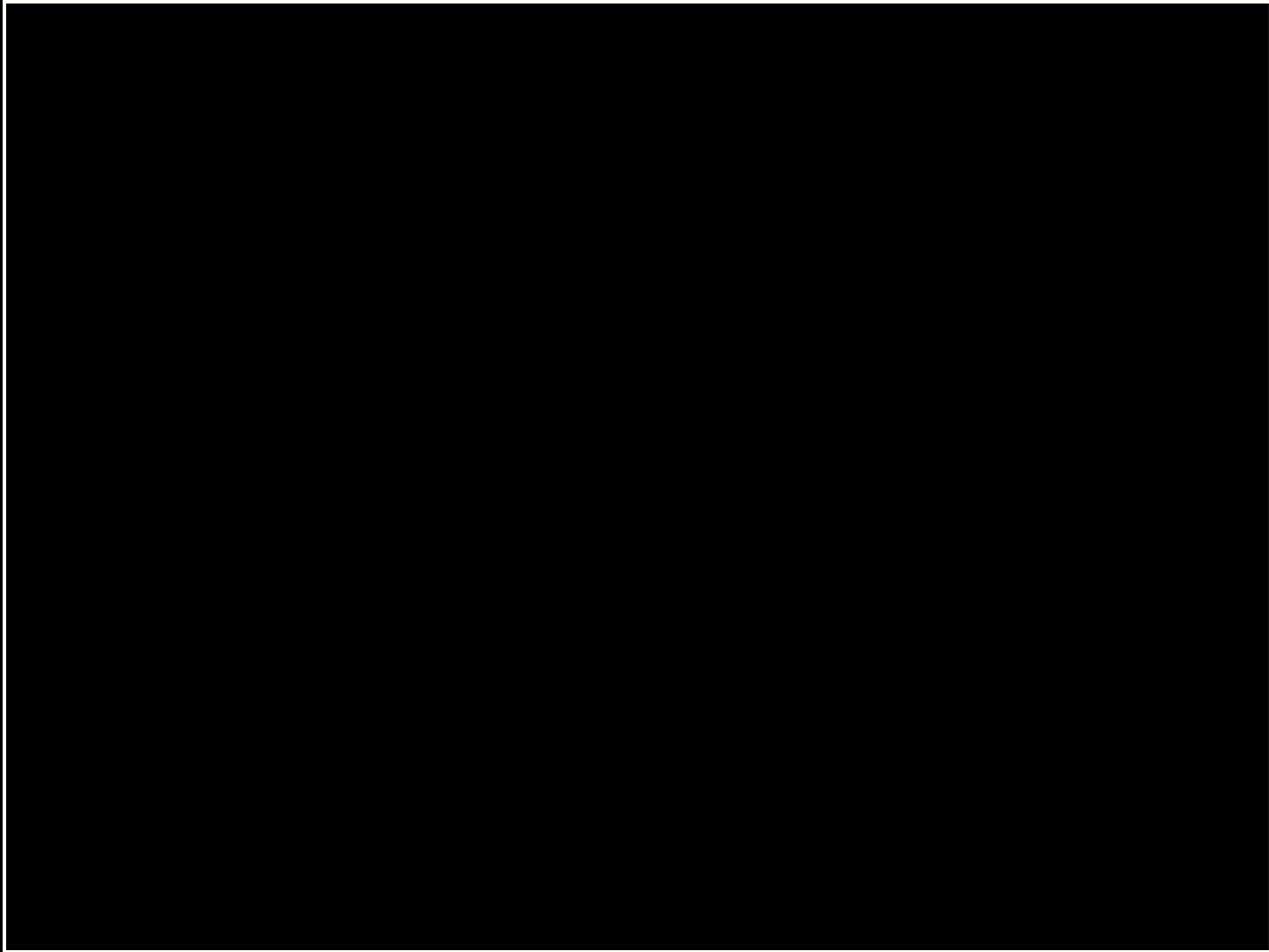
Nutrient Transport



Insect Pest Control

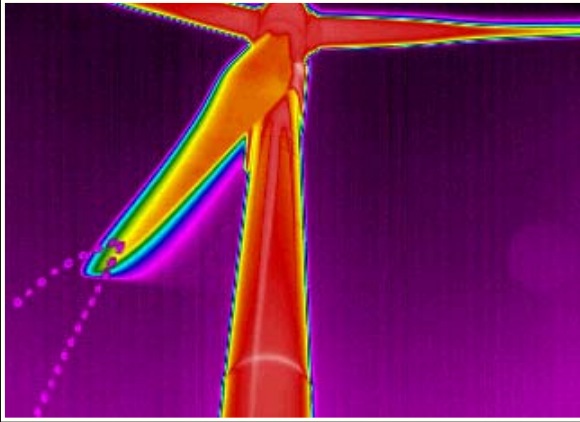


Seed Dispersal



Ecotourism

Bats Are Being Killed by Wind Turbines



Trajectory of a bat struck
by the blade of a modern
wind turbine



Photo by Ed Arnett



Photo by Jessica Kerns

Hoary bat

Collecting dead bats killed at
wind energy facilities

Fatality Assessment

- Search Area and Pattern
- Search Frequency
- Searcher Efficiency
- Corrections for Observer Bias
- Corrections for Scavenger Removal
- Species Identification



Photo by Jessica Kerns

Hoary bat



Photo by Ed Arnett

Collecting dead bats killed at
wind energy facilities



Photo by Ed Arnett

Eastern red bat

Hypotheses Why and How Insectivorous Bats Are Being Killed by Wind Turbines?

- Roost Attraction
- Acoustic Attraction
- Linear Corridor
- Insect Concentration
- Sensory Failure
- Insect Entrapment

Roost Attraction Hypothesis

Bats are Attracted to Wind Turbines During Migration
Because they are Perceived as Roost Trees?



Wind Turbine

(Photo from Morrison and Sinclair, 2004)



Roost Trees

(Photo courtesy of Maarten Vonhof)

Acoustic Attraction Hypothesis

Bats are attracted to sounds (audible and/or ultrasound) produced by wind turbines



(Photo from Morrison and Sinclair, 2004)

- Uniform and constant sounds made by turbine generator
- Variable swishing sounds made by rotating blades

Linear Corridor Hypothesis

- Linear corridors (roadways and right-of-ways) are created along forested mountain ridges as part of land-based wind farm site development
- Some bat species (especially red and hoary bats) are known to forage along linear landscapes
- Migratory bat species also may use linear landscapes (including mountain ridges) as sensory cues
- Roadways created in forested regions as part of wind farm development, or mountain ridges, may increase risks to bats of encountering wind turbines



(Photo from Morrison and Sinclair, 2004)

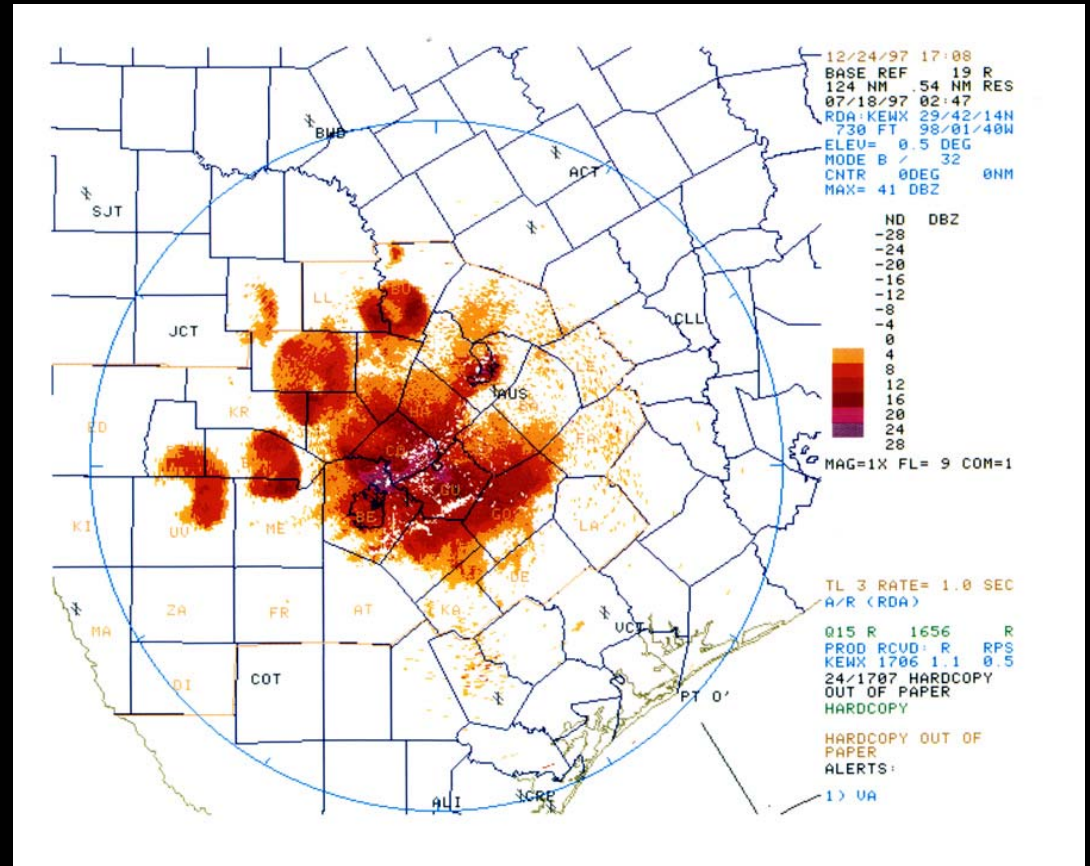
Bats at Risk

Why Should We Care?

Uncertainties

- Reduced Biodiversity?
- Reduced Ecosystem Services?
- Cumulative Impacts?

Nightly Dispersal of Brazilian Free-tailed Bats from Maternity Roosts in South-central Texas



Based on NEXRAD Doppler Radar

What Should We Conserve?

Species?

Populations?

Metapopulations?

Assemblages?

Genetic Diversity?

Life History Traits?

Species Richness?

Species Diversity?

Habitats?

Landscapes?

Ecosystems?

Summary

- Wind energy is one of the fastest growing sectors of the energy industry
- Large numbers of migratory tree bats have been killed at commercial wind power facilities
- Research needs are identified to help inform researchers, developers, regulatory agencies, and other stakeholders
- Research should focus on regions and sites where existing and new information suggest high potential for adverse impacts on bats
- Hypothesis-based research is needed to address these concerns

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Merlin Tuttle



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